PATENT APPLICATION

Method of Detecting and Measuring a Moving Object and Apparatus Therefor, and a Recording Medium for Recording a Program for Detecting and Measuring a Moving Object

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METHOD OF DETECTING AND MEASURING A MOVING OBJECT
AND APPARATUS THEREFOR, AND A RECORDING MEDIUM FOR
RECORDING A PROGRAM FOR DETECTING AND MEASURING
A MOVING OBJECT

BACKGROUND OF THE INVENTION

The present invention relates to an accident
and crime preventive technique for measuring the height
of vehicles at the entrances of parking lots, measuring
5   the height of people going on board vehicles, and
monitoring shops and roads, also relates to a method
and apparatus for detecting and measuring moving
objects for analysis of images taken by cameras, and
further concerns a recording medium for recording a
10 program for detecting and measuring a moving object.

Investigations are being made to impose
height limits for cars and human beings at the
entrances of parking lots or at the doors of wagons in
the amusement parks, etc. A criminal's height is
15 judged by visual measurement from ex post facto images
recorded by time plus video recorders for surveillance
in convenience stores and so on. Further, In addition
to the admission regulations in terms of height, there
are vehicle admission regulations for narrow road
20 widths.

In the parking lots, poles and sign boards
are provided, which limit the height of entering

vehicles. At the entrance to a parking lot, when the
car contacts the height-limiting pole, for example, a
warning is given to the driver, or information is
supplied to the attendant to make a decision to refuse

5 admission or to designate another parking area. At the
entrance to vehicles in an amusement park, there is
sometimes what may be called a height check board
having a hole in the shape of a human being to limit
the height of people going on board, and by comparing

10 with a height comparison-purpose panel, a warning is
issued to a person concerned or information is supplied
for the attendant to refuse admission for security
reasons. In convenience stores, there is a color-
classified height measuring tape at the exit, the

15 customers are monitored at all times by a monitor
camera and a time plus video recorder. After an
incident has occurred, the height of a criminal is
determined by visual measurement from the recorded
images. On narrow-width roads, there are signs

20 prohibiting the entrance of vehicles or large-sized
vehicles. The comparison-purpose panels, stickers, and
road signs are intended to preclude incidents or gather
information by measuring the height or the width of
objects, which are going to enter, in specified places

25 (hereafter referred to as moving objects). Under
present circumstances, however, analysis of image
records has to rely on visual inspection or decision by
a human being for technical reasons. Therefore, there

has been demand for automated measuring process using a computer, and various methods have been proposed.

As a method for detecting a moving object, there has been proposed "Apparatus and Method for Detecting and Extracting a Moving Body" in JP-A-8-221577. This method realizes detection and extraction of the feature of a moving object against a complicated background and also realizes a reduction in image processing time. Referring to Fig. 2, this method will be described in the following.

In Fig. 2, frame images F1 (241) to F7 (245) are the frame images of the images taken at time T1 (221) to T5 (225). A segment S (231) in the frame image in Fig. 2 is designated as that area of the input image to which attention is directed in monitoring, and this area of interest is hereafter referred to as a slit. Reference numerals 201 through 205 in Fig. 2 denote slices of images at the slit (hereafter referred to as slit images) and a background image taken at time T1 (221) through time T5 (225). In this example, the image of the area of interest in monitoring when no moving object is not being captured by the camera is set as the background image at the start of processing.

In this method, the following steps are carried out on each frame image. (1) Slit images and the corresponding portions of the background images in a specific frame are extracted, (2) an extent of variation in the image structure of the slit image and

the background image is obtained, (3) when the amounts
of structure variation in those images are viewed as
time series, if the image structure variation appears
in the form of waves, it is decided that there -is a
5   moving object, and (4) when the image structure
variation is flat without showing any change, it is
decided that the background with no moving object
superposed is shown.

The step (3) will be described using a
10 sequence of frame images in Fig. 2. When an object
moves across the slit as in this example, the image
structure variation appears in a wavy pattern as shown
in the image structure change graph (211) in Fig. 2.

The image structure variation here is a
15 measure by which to indicate to what extent the struc-
ture of an object, such as the position or shape of an
object in the image, has changed. The image structure
variation is a feature quantity not affected by
illuminance, and differs from an image variation
20 representing a variation in pixels in the image. The
method of calculating the image structure variation
will be described in detail later on.

Before an object comes into the slit (time T1
(221)), the image at the slit and the corresponding
25 portion of the background image are almost the same
(201), the image structure variation is little. Then,
when the object starts to cross the slit (time T2
(222)), the slit image differs from the background

image (202), and image structure variation becomes
large. Finally, when the object has passed through the
slit (time T3 (223)), the image structure variation
returns to a small value. As an object passes through
5 the slit, the image structure variation changes in a
wavy pattern. Therefore, to find a moving object, it
is only necessary to observe the image structure
variation as a time series and find a change in an
upward convex form. In this example, to recognize this
10 upward convex change, the moment when the image struc-
ture variation exceeds a threshold value a (213) and
the moment when it falls below the threshold value a
(213) are used.

         The step (4) mentioned above will be
15 described using the sequential frame images shown in
Fig. 2. If a baggage (252) is left to stand about the
slit as in this example (time T4 (224)), the image
structure variation is large at first, but because the
baggage (252) is at a standstill, the image structure
20 variation remains unchanged at a high level (from time
T4 (224) till time T5 (225)). In this method, when the
value of the image structure variation has been small
for more than a fixed time period as in this example,
the background is changed automatically by using the
25 slit image at this point in time as the background.

         Lastly, the method for calculating the image
structure variation in the step (2) will be described
with reference to Figs. 13A, 13B, 13C, 14A, 14B, 14C

and 15. Figs. 13A, 13B and 13C show the effects that
the changes in illuminance have on the slit images.
Let us consider a slit 1301, in which the illuminance
of each pixel is expressed by P1 ... PN as shown in

5 Fig. 13A. If we draw a graph in which the vertical
axis indicates the positions of the pixels and the
horizontal axis indicates the illuminance of the
pixels, we have a graph of a slit image 1305 in Fig.
13B. Supposing the slit image 1301 as a whole becomes

10 dark due to a sudden change in illuminance, such as by
a shadow, the graph 1301 undergoes a uniform decrease
from 1305 to 1307 while retaining the relative
illuminance levels among the pixels P1 through PN as
shown in Fig. 13C. This change in illuminance can be

15 illustrated as shown in Figs. 14A, 14B and 14C by
expressing the slit image by vector notation.

As shown in Fig. 14A, the slit image can be
regarded as a vector V (1401) made up of unit vectors,
which represent the illuminance of the pixels. If base

20 vectors of the pixels P1 through PN are designated as
b1, b2, b3 ... bn, the vector (1401) can be expressed
as a point in a n-dimensional vector space as in Fig.
14B. Then, let us suppose that a shadow fell over the
slit image and the illuminance changed suddenly, with a

25 result that the slit vector V (1401) changed to a slit
vector V' (1403) as shown in Fig. 14C. At this time,
from observations of Fig. 3, the changed slit vector V'
(1403) can be considered to be almost on the same

segment as the vector V (1401) and also considered to
be a scalar multiple of the vector V (1401).   The slit
vector V' (1403), formed as a result of a change in
illuminance in the original slit vector V 1401, remains
5   in almost the same direction even though the slit
vector V' (1403) is located at coordinates greatly
different from the coordinates of the vector V (1401)
in the vector space.   In contrast, a slit vector, which
has undergone a structural change, is considered to be
10   different not only in coordinate values but also in
direction.   Therefore, to differentiate a change in
illuminance from a change in structure in the slit
image 1301, it is only necessary to know whether there
is a change in the direction of the vector.

15   Fig. 15 shows an ordinary slit vector V
(1401) and the slit vector V' (1403) affected by a
change in illuminance, and their projected shadows on a
unit sphere.   As shown in Fig. 15, the distance PQ
between a projected vector P (1501) on the unit sphere
20   as a shadow of the vector V (1401) and a projected
vector Q (1503) on the unit sphere as a shadow of the
vector V' (1403) is much closer to each other than the
original distance VV'.   What occurred in the two slit
images, which differentiates one from the other, that
25   is, whether a difference occurred due to a change in
illuminance or a structural change, can be decided by
finding whether or not the distance between the
projected vectors on the unit sphere is very small.

The normalized distance between the vectors is here-
after referred to as a normalized distance. By using
the normalized distance, the degree in which a
structural change occurred in an objet in an image can
5 be obtained. In this method, the image structure
variation is used in detection of a moving object in
the step (3) or in detection and automatic changing of
the background image as mentioned in the description of
the step (4). Thus, at the time of changeover of the
10 lighting condition from day to night or night to day or
under the condition that an object is placed at the
background position, which has conventionally made
monitoring difficult, it becomes possible to correctly
decide whether there is a moving object, whether there
15 is a new background or whether the change is merely by
a shadow.

The outline of "Apparatus and Method for
Detecting and Extracting a Moving Object" has been
described. In this method, a segment can be used as an
20 area of interest to be monitored; therefore compared
with the conventional method, which uses the whole
screen image as an area of interest, it becomes
possible to greatly reduce time for calculation of the
image structure variation. Further, in this method, by
25 monitoring changes on the time base of the image struc-
ture variation, it is possible to find timing for
changing the background and therefore even in places
where the background is likely to be changed, as in

taking pictures outdoors, a monitor process can be applied. In this method, because image variations as difference amounts of the pixels are not used but degrees of structural change in the object in the image

5 are used, the background and the moving object can be distinguished from each other even when the lighting condition is changed or a structural change occurred in the background image.

Further, "Apparatus and Method for Detecting

10 and Extracting a Moving Object by Using Combined Information" have been disclosed in JP-A-11-134506. In this method, there have been provided a plurality of areas of interest used in the moving object detecting apparatus, and the position and the size of a moving

15 object are decided from a combination of some pieces of moving object detection information captured by the lattice-type monitoring areas. This method will be described with reference to Fig. 3.

In Fig. 3, the vertical position and the

20 horizontal position of a moving object 341 in an input TV screen image 300 are detected by using a group of slits (311 through 315 and 321 through 324) arranged in a lattice form. This group of slits are formed by arranging a group of vertical slits, arranged like

25 vertical lines, such as slit V1 (311), slit V2 (312), slit V3 (313), slit V4 (314) and slit (315), so as to be perpendicular to a group of horizontal slits, arranged like horizontal lines, such as slit H1 (321),

slit H2 (322), slit H3 (323) and slit H4 (324). The
vertical slits are arranged in parallel spaced apart by
a distance of Lw (332). Similarly, the horizontal
slits are arranged in parallel spaced apart by a height
5   of Lh (331).

In Fig. 2, while the image structure varia-
tion is higher than the threshold value a (213),
specifically, an interval from time T2 (222) till time
T3 (223) and an interval on and after time T4 (224),
10   moving object detecting means continues issuing a
moving object detection event (for example, if there
are 30 picture frames per second, those frames are
checked one frame after another to see if there is a
moving object. While the image structure variation is
15   higher than the threshold value, a signal indicating
that a moving object is detected continues being
issued.)

As a slit identifier of moving object
detection information, character strings indicating
20   names of the slits, such as "V1", "V2", "H1" and "H4",
are set to identify each of the slits shown in Fig. 3.

Description will now be made of a method for
deciding the size of a moving object by using the slits
mentioned above. In Fig. 3, in the case of a moving
25   object 341, the vertical slits V2 (312) and V3 (313)
and the horizontal slits H2 (322) and H3 (323) are
detected. Among the vertical slits, the slit V1 (311)
at the left of the slit V2 (312) and the slit V4 (314)

at the right of the slit V3 (313) are not detected.
Among the horizontal slits, the slit H1 (321) above the
slit H2 (322) and the slit H4 (324) below the slit H3
(323) are not detected. The width of the moving object

5   is known to be greater than the width Lw (332) accord-
ing to the detected vertical slits V2 (312) and V3
(313) and less than twice the width Lw (332) according
to the vertical slits V1 (311) and V4 (314) not
detected. The height of the moving object is known to

10 be greater than the height Lh (331) according to the
detected horizontal slits H2 (322) and H4 (324) and
less than twice the height Lh (331) according to the
horizontal slits H1 (321) and H4 (324) not detected.

        Description has been made of the outline of

15 "Apparatus and Method for Detecting and Extracting a
Moving Body by Using Combined Information" by which to
decide the size of the moving object. In this method,
the height, width and position of a moving object is
determined by using a combination of multiple pieces of

20 information obtained from input images captured by a
lattice-type moving object detecting means. With this
method, because decisions are made on the time base, it
is possible to keep track of a moving object on the
input TV screen image.

25 SUMMARY OF THE INVENTION

        When the above-mentioned prior art is put
into practice in a simple way, there are problems as

follows. The first problem is that depending on the
shape of a moving object, it may occur that it is
impossible to decide when to measure an effective
height for a moving object to pass the area of
5 interest. The second problem is that when the height
is to be measured with high accuracy by defining a
plurality of areas of interest in a lattice form and
using a combination of measurement results obtained, it
is necessary to define many areas of interest in a
10 lattice form, so that it takes time to make a decision
by using a combination of measurement results.

        As means that constitute the present inven-
tion, there are provided a means for receiving video
images and other pictorial images from outside and a
15 plurality of means for defining an object under
detection on a single straight line, consisting of a
base line and its partitions (division lines), in an
input video image or a pictorial image and detecting a
moving object. Further, a moving object measuring and
20 deciding means is provided, which encodes a moving
object detection result output from the detecting means
and compares this code of detection result with a
preset measurement code to decide presence or absence
of a moving object. Also provided is a means for
25 outputting a decision result to outside. By this
arrangement, the height and so on of a moving object
can be measured.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is an example of block diagram of a moving object detecting and measuring apparatus;

Fig. 2 shows an example showing how a moving object detecting means in Fig. 1 is realized;

Fig. 3 shows an example of a moving object size detecting method in a means of making a combined decision on a moving object;

Fig. 4 shows an example of an image structure maximum variation method in the moving object detection means;

Fig. 5 shows an example showing how slit detection information is formed;

Fig. 6 shows an example showing how to define a measurement code;

Fig. 7 shows an example showing how to define a slit and how to generate a measurement code from detection information;

Fig. 8 shows another example showing how to define a slit and how to generate a measurement code from detection information;

Fig. 9 is a flowchart showing an example of a process of measuring the height of a moving object from information from the base line and its partitions;

Fig. 10 shows an example of a screen image of a vehicle height measuring guide system at the entrance of a parking lot;

Fig. 11 shows an example of a screen image

specifying the partitioning points for the base line
and its partitions;

Fig. 12 shows an example of a screen image
specifying the starting point for the base line and its
5   partitions;

Figs. 13A, 13B and 13C are examples of
diagrams for explaining the effects of changes in
illuminance on the slit images;

Figs. 14A, 14B and 14C are examples of
10 diagrams showing the effects of changes in illuminance
on the slit vectors when the slit images are expressed
by vector notation; and

Fig. 15 shows an example of a diagram showing
mapping on a unit sphere of a normal slit vector and a
15 slit vector affected by a change in illuminance.

DESCRIPTION OF THE EMBODIMENTS

The embodiments will be described in the
following.

Description will start with an example of a
20 means for deciding and measuring apparatus.

Fig. 1 is a block diagram the moving object
detecting and measuring apparatus. Fig. 4 shows an
example of changes in the image structure variation
from predicted entry until after entry in detection at
25 the base line. Fig. 5 shows an example of a sequence
of slit definition and detection information used in
the moving object detecting means. Fig. 6 shows an

example of a measurement code table used in the means
for coding a detection result. Figs. 7 and 8 show
examples of means for defining video images on the same
line serving as the base line and its partitions
5   (division lines). Fig. 9 shows an example of a proce-
dure for coding detection results at the base line and
its partitions in a frame when the image variation is
at its greatest value in a time span from when a moving
object is going to enter the slit till its entry during
10   detection at the base line and comparing a code of the
detection result with a preset measurement code to make
a decision.

        Referring also to other figures, description
will be made of the structure of the moving object
15   detecting and measuring apparatus (100) in Fig. 1 as
one embodiment of the present invention, which can be
realized in actuality by a computer.

        The moving object detecting and measuring
apparatus (100) is formed by the following means. An
20   image input means (111) performs a function to read
into the moving object detecting and measuring
apparatus (100) images generated by an image generating
means formed by a video camera (110).

        In this case, the images of the video camera
25   (110) are input to the image input means (111). The
read images in the image input means (111) are input,
as a sequence of frame images that form pictures, to a
moving object detecting means (113) installed in a

detection position setting means (112) and are checked
to see whether there is a moving object or not.
Similarly, an image read into the image input means
(111) is input to the i-th moving object detecting
5   means i and checked for any moving object. The moving
object detecting means 1(113) calculates correlation
between data at the area of interest in a specified
input frame and data at the area of interest in each
frame, and from at least one pattern of correlation
10 values, a decision is made as to a moving object
detection event, such as presence or absence of a
moving object or a change of the background image. To
realize this, in this embodiment, the method shown in
Fig. 2 is used, which has been described when prior art
15 was mentioned. As moving object detection events that
can be obtained as a pattern of correlation value to be
output (114) from the moving object detecting means 1
(113), there are various events can be conceivable,
such as a point in time when a moving object contacts
20 the base line slit, or another point in time when a
moving object comes out of the slit, or yet another
point in time when the background has been changed.

        To explain this using Fig. 2, the point in
time when a moving object comes into contact with the
25 slit can be detected as a point in time when the image
structure variation becomes higher than the threshold
value a (213) (time T2 (222), frame image F2 (242)).
Similarly, the point in time when the moving object

comes out of the slit can be detected, after the image
structure variation exceeded the threshold value a
(213), as a point in time when the image structure
variation falls below the threshold value a (213) (time
5   T3 (223), frame image F3 (243)). Again similarly, the
point in time when the background has been changed is
detected, after the image structure variation moved
ahead of the threshold value a (213), as a time in
point when the image structure variation remains flat
10 for several seconds (for several frames) (time T5
(225), frame image F5 (245)).

         In this embodiment, the video camera (110) is
installed at a fixed position in such a way as facing
the door of a convenience store or a vehicle. People
15 pass a limited place such as the door of a convenience
store or a vehicle. Therefore, the distance between
the video camera (110) and each subject person is
presumed to be almost the same at all times. For this
reason, with the position where people walk through in
20 mind, the base line and each partition are set as the
area of interest to detect subjects.

         Further in this embodiment, a detection
position setting means (112) has an image defined by
the base line and its partitions formed on the same
25 straight line. The keyboard (115) and the mouse (116)
are used to set the detection positions on an input
image supplied as shown in Fig. 1. More specifically,
in Fig. 7, when the areas of interest used by the

definition lines, made up of the base line and its
partitions, are to be arranged on the same line, the
start point and end point of the base line V0 (710) are
defined in the first place. Then, the partition V1
5 (721) through the partition V5 (725), being formed by
dividing the base line V0 (710), are defined as
follows.

With the partition V1 (721), its start point
is set at the same position as the start point of the
10 base line V0 (710) and its end point is defined anew.
For the partition V2 (722), its start point is set at
the same position as the end point of the partition V1
(721) and its own end point is defined anew. For the
partition V3 (723), its start point is set at the same
15 position as the end point of the partition 2 (722) and
its own end point is defined anew. For the partition
V4 (724), its start point is set at the same position
as the end point of the partition V3 (723) and its own
end point is defined afresh. For the partition V5
20 (725), its start point is set at the same position as
the end point of the partition V4 (724) and its own end
point is defined at the same point as the end point of
the partition V0 (710). For clarity of illustration,
those partitions are shown separately from the base
25 line V0, but the lines V1 through V5 are actually
located on the same position as the base line V0.

Referring to Table 701, description will now
be made of the relation among the defined positions,

the measurement code and the heights obtained by actual

detection and measurement of heights. The base line V0

is defined as ranging from 0.0m to 2.0m, the partition

V1 as ranging from 0.0m to 1.6m, the partition V2 as

5   ranging from 1.6m to 1.7m, the partition V3 as ranging

from 1.7m to 1.8m, the partition V4 as ranging from

1.8m to 1.9m, and the partition V5 as ranging from 1.9m

to 2.0m. The types of detection in Fig. 5 obtained by

the moving object detecting means in Fig. 2 are "before

10   entry" = 0 and "entry" = 1. A detection type at the

slit in each frame image is passed to a measurement

code table in Fig. 6. Therefore, information about

height in a measurement code "000000" is "before

passing through", height information of a measurement

15   code "110000" is "under 1.6m", height information of a

measurement code "111000" is "1.6m or more and under

1.7m", height information of a measurement code

"111100" is "1.7m or more and under 1.8m", height

information of a measurement code "111110" is "1.8m or

20   more and under 1.9m" and height information of a

measurement code "111111" is "1.9m and over".

"Entry" and "before entry" have been outlined

and will be described in detail with reference to Fig.

5.

25   Fig. 5 shows a sequence of moving object

detection events (slit definition and detection infor-

mation) contained in the moving object measuring and

deciding means (101). The slit definition and detec-

tion information includes multiple pieces of moving
object detection information, generated by the moving
object detecting means, in a list structure. The slit
definition and detection information has a start
5   pointer 500 indicating a leading end thereof, and has a
piece of moving object detection information as one
element of the list structure, and has the respective
elements concatenated by pointers. In the example in
Fig. 5, the elements 501 and 502 here are event list
10   elements, and the event list elements are chained
together by the start pointer 500 and the next pointer
area next (551) of an element 501 and so on. In this
example, the base line corresponds to a means 1 of the
slit ID (552) of the slit definition and detection
15   information, and the partitions are assigned to means 2
through the last means of the slit definition and
detection information.

The means 1, means 2 and so on denote the
moving object detecting means 1 (113) ... n (123).
20   The event lists (501), (502) and so on each
correspond to one of the partitions V0 to V5 and they
are chained together so that they can be searched
sequentially by the pointers 551. Note that the black
dots indicate the pointers in Fig. 5. By the slit ID
25   (552), the base line and its partitions are given IDs,
starting with means 1 for V0 and means 2 for V1 and so
on. With regard to a detection type (553) when a
moving object enters a slit of any slit No., informa-

tion "entry = 1" is written in the detection type
field. If there is no moving object in the slit,
information "before entry = 0" is written. The image
structure variation (554) is numerical representation
5 of to what degree a moving object has entered the slit.
If there is no moving object at all, the value 0 is
written. As the quantity of a moving object that
appears in the image in the slit increases, the value
increases.

10   The definition mode (555) indicates whether
the slit is defined as shown in Fig. 7 or as shown in
Fig. 8. The number of partitions defined (556)
indicates the number of partitions defined in the slit.
In this example, the number is six, V0 to V5, so six is
15 written.

          The start point X (557) and the start point Y
(558) indicate where the start point of the slit is
located in the screen image. In the case of an event
list (501), it is shown that the start point is set at
20 a position 160cm in the X direction and 5cm in the Y
direction from the origin (0,0) placed at the lower
left corner of the screen. The end point X (559) and
the end point Y (560) indicate the end point of the
slit is at a position 160cm in the X direction and
25 235cm in the Y direction from the origin. In the case
of an event list (502), the start point is located at a
position 160cm in the X direction and 180cm in the Y
direction from the origin, and the end point is located

at a position 160cm in the X direction and 235cm in the
Y direction from the origin. The those numeric values
can be set from the keyboard 115. The latest slit
image (561) is the pointer to a slit image (511) and
5   the background slit image (562) is the pointer to a
slit image (512) as the object to compare with.
Further, the frame image (563) is the pointer to a
frame image (513).

The measurement code, which was mentioned
10 above, will be described in detail with reference to
Fig. 6.

Fig. 6 shows an example of a measurement code
table (600) used in the means for coding a detection
result. From slit detection information, detection
15 types (553) of the slit definition and detection
information, which generates a measurement code on the
base line and its partitions, are passed to a measure-
ment code made from detection result. The number of
digits of the measurement code table (600) is the
20 number of partitions defined (556). It ought to be
noted that the two types of detection are before entry
(0 is set) and entry (1 is set). In this example,
because the number of partitions defined is six, six
detection types are passed from the slit detection
25 information, more specifically, the detection type of
the base line to the sixth digit and the detection
types for the partitions 1 through 5 to the first to
fifth digits of the measurement code.

Referring to the reference numerals, the
structure of the measurement code table will be
described. When a moving object is detected in any
part of the range of the slit V0, 1 is set in bit
5 (610). Similarly, when a moving object is detected in
the range of the slit V1, 1 is set in bit (611).
Hereinafter, similarly, when a moving object is
detected in any other slit, 1 is set to the correspond-
ing one of bit (612) to bit (615). Therefore, the
10 measurement code table (600) is formed by a bit
pattern, each bit representing entry or before entry.

Figs. 7 and 8 show difference modes of
embodiment, which have different ways of setting the
partitions. Referring to Fig. 8, when the areas of
15 interest used by the definition lines, including the
base line and its partitions, which have varying
lengths, are arranged on the same line superposed one
on top of another. To begin with, the start point and
the end point of the base line V0 (810) is defined.
20 Then, the partitions from V1 (821) to V5 (825) are to
be defined. Because those lines have the end points at
the same position as the base line V0 (810), definition
can be done in a manner described below. The partition
V1 (821) is defined as having its start point at the
25 same position as the start point of the base line V0
(810) and its end point at the same position as the end
point of the base line V0 (810). The partition V2
(822) is defined as having its start point at a

position that makes its length shorter than the parti-
tion V1 (821) and its end point at the same position as
the end point of the base line V0 (810). The partition
V3 (823) is defined as having its start point at a
5   position that makes its length shorter than the parti-
tion V2 (822) and its end point at the same position as
the end point of the base line V0 (810). The partition
V4 (824) is defined as having its start point at a
position that makes its length shorter than the parti-
10 tion V3 (823) and its end point at the same position as
the end point of the base line V0 (810). The partition
V5 (825) is defined as having its start point at a
position that makes its length shorter than the parti-
tion V4 (824) and its end point at the same position as
15 the end point of the base line V0 (810).

        Referring to a table at 801, for example,
description will be made of the relation among the
defined positions, the measurement code and the heights
obtained by actual detection and measurement of
20 heights. The base line V0 is located from 0.0m to
2.0m, the partition V1 is located from 0.0m to 2.0m,
the partition V2 is located from 1.6m to 2.0m, the
partition V3 is located from 1.7m to 2.0m, the parti-
tion V4 is located from 1.8m to 2.0m, and the partition
25 V5 is located from 1.9m to 2.0m. The detection types
in Fig. 5 obtained by the moving object detecting means
in Fig. 2 are before entry (0) and entry (1). The
detection types of slit lines in each frame are passed

to the measurement code table in Fig. 6. Therefore,
information about height of a measurement code "000000"
is "before passing through", height information of a
measurement code "110000" is "under 1.6m", height
5 information of a measurement code "111000" is "1.6m or
more and under 1.7m", height information of a measure-
ment code "111100" is "1.7m or more and under 1.8m",
height information of a measurement code "111110" is
"1.8m or more and under 1.9m" and height information of
10 a measurement code "111111" is "1.9m and over.

　　　　Optimum frame information of the maximum
image structure variation in detecting the base line,
as shown in Fig. 4, for example, a period when a moving
object is in contact with the slit is from a point in
15 time when the image structure variation in Fig. 4
exceeds a certain threshold value a (413) (frame image
F2 (442)) until the moving object gets out of the slit,
in other words, until a point in time when the image
structure variation falls below the threshold value a
20 (413)(frame image F4 (444)). More specifically, by
comparison of the image structure variations of the
adjacent frames in the above-mentioned period, informa-
tion about the point in time when the image structure
variation is greatest (frame image F3 (443)) can be
25 obtained.

　　　　The moving object detecting means 1 (113) to
n (123) passes detected moving object detection events
along with moving object detection information, such as

kinds of moving object detection events and frame
images in which detection occurred, to the moving
object measuring and deciding means (101).

5   Moving object detection information in this
example, as shown in one element (501) of slit defini-
tion and detection information in Fig. 5, includes an
identifier id (552) of the moving object detecting
means (hereafter referred to as slit ID, realized by a
character string), a type (553) of a moving object
10   detection event detected at the time of contact with
the slit or a change of the background, the image
structure variation ci (554) in each frame image, a
mode (555) (setting partitioning points or starting
points) of defining the base line as partitions, the
15   number ti (556) of the defined base line and parti-
tions, the start points X xbi (557) of the base line
and its partitions, the start points Y ybi (558) of the
base line and its partitions, the end points X xbi
(559) of the base line and its partitions, the end
20   points Y ybi (560) of the base line and its partitions,
the slit image slit (561) and the background image bgr
(562) used for the moving object detection process, and
the frame image img (563).

In this example, the slit image slit (561),
25   the background image bgr (562) and the frame image img
(563) are realized as pointers to actual image data and
they point to the images 511, 512 and 513.

Moving object detection events and accompany-

ing moving object detection information (114, 124,
etc.) output from the moving object detecting means are
coded by the moving object measuring and deciding means
101, compared with a preset measurement code, and

5 decision results are output as advanced moving object
detection events (102). The result output means (103)
supplies the user with final moving object detection
and measurement results obtained from advanced moving
object detection events (102) through a display unit

10 (104) or a speaker (105).

In this example, the above-mentioned moving
object detection and measuring apparatus (100) is
realized by a computer formed by a memory, an input/
output device, and an arithmetic unit.

15 Following the steps starting with step 900 in
Fig. 9, description will be made of a procedure for
arranging the areas of interest used by the definition
lines, including the base line and its partitions in
Fig. 8, on the same line by having those lines super-

20 posed one on top of another with their lengths varying
from the reference point.

Detection information about the slit of the
base line and its partitions is obtained from each
frame (901). A decision is made whether the detection

25 type of the base line is entry or not (902). If not
entry, all digits of the measurement code are set to 0
(903). Information of "before entry" is passed to the
result output means (904), and slit detection informa-

tion of the next frame is obtained. If the detection
type is entry, a measurement code shown in Fig. 6 is
generated from the detection information of the slit of
the base line and its partitions (905). Then, a

5 decision is made whether the image structure variation
of the base line shown in Fig. 5 is greatest or not
(906). If the variation is not greatest, detection
information about the slit of the next frame is
obtained. If it is greatest, information about the

10 relation among detected information, the preset
measurement code and the preset measurement code is
obtained (907). Next, a decision is made whether the
detected measurement code is the same with the preset
measurement code or not (908). If not the same, the

15 next preset measurement code and information about
height are obtained. If the codes are the same,
measurement information about comparison results is
passed to the result output means (103) (909).
Finally, a decision is made whether there is no more

20 frame image (910). If there is some frame image
remaining, slit detection information of the next frame
is obtained. If no more frame image remains, this
procedure is finished. Output of the result output
means (103) is shown on the display (104), and supplied

25 to a speaker, a printer or an external output means
(105) as transmission equipment to a remote place.
According to a result by the measuring and deciding
means, the external output means outputs a result on

the display or issues a warning or guidance.

Note that information about preset measure-
ment codes and heights is prepared for each measurement
code and stored as table data. A measurement code
obtained from detection information is compared with a
preset measurement code. How a measurement code is set
will be described in detail in the following embodi-
ment.

As another embodiment of the present inven-
tion, description will be made of an example of a
result output method of detection, measurement and
decision at a slit made of one base line and two
partitions that define an image and also of an example
of slit definition. Fig. 10 shows an example of a
screen image for defining the base line and two parti-
tions, measuring the height of a vehicle and displaying
a parking lot specified.

This example shows a case of examining the
height of an automobile. A video camera is installed
facing a very limited space where automobiles pass
through at the entrance of a parking lot, for example.
Therefore, the distance and the positional relation of
the video camera with respect to automobiles is assumed
to be almost constant.

Fig. 11 shows an example of a screen image,
in which the area of interest used with the definition
lines, including the base line and its partitions, are
arranged on the same line and the displayed items of

the measurement code are set. Fig. 12 shows an example
of a screen image, in which the areas of interest used
with the definition lines, including the base line and
its partitions, which have varying lengths, are
5 arranged on the same line superposed one on top of
another, and the displayed items of the measurement
code are set.

Fig. 10 shows a screen image of results
output by the detection and measuring apparatus of the
10 slit made of the base line and its partitions for
defining an image. The window (1000) is an area
showing the results displayed by a computer, for
example. The window (1000) includes an area (1001)
showing an input image, a measure start button (1003)
15 that initiates measurement of the height of a moving
object, an examine end button (1004) for terminating
the examination, a measuring line set button (1005) for
setting a measuring line, a selected slit (1002) in the
input image (1001), and an area (1006) for showing a
20 measurement result for each vehicle by a frame image
that shows a measurement code and the height of a
moving object, a parking lot specified, etc. The
selection of the position of the slit (1002) in the
input image (1001) will be described in detail with
25 reference to Figs. 11 and 12. When the measure start
button (1003) is depressed, the measuring process of
the height of a moving object starts. When the measure
end button (1004) is depressed, the measuring process

is finished.

The measuring process will be described briefly. At the start of measurement, it is assumed that the frame image, measurement code, vehicle height, and a parking lot designated in the measurement result area (1006) are initialized and blank. Afterward, each time a moving object is detected (in a frame when the image structure variation is greatest), the moving object detection and measurement information is added to the measurement result area (1006) on the display screen.

In this embodiment, when moving object detection information is displayed, as shown at 1021 in Fig. 10, the measured frame image, measurement code, vehicle height, and a parking lot designated are arranged from top down in this order.

In the process of outputting moving object detection and measurement results, it may be further arranged that to issue a warning based on the measure-ment code, the characters in the measurement result area (1006) or its square frame flickers or a speaker is used to draw attention.

Description will then be made of a screen image, in which the areas of interest used by the definition lines, including the base line and its partitions, in Fig. 11 are arranged on the same line superposed one on top of another, and the displayed items of the measurement code are set. The window

(1100) is an area where the displayed items of the slit
and the measurement code are set from a computer, for
example.

The window (1100) includes an area (1101) for
showing a definition image, a check box (1106) for
selecting a definition mode to set a definition method,
the edit boxes (1107) capable of inputting the coordi-
nates of the base line-0 slit, the edit boxes (1108)
capable of inputting the coordinates of the partition-1
slit, the edit boxes (1109) capable of inputting the
coordinates of the partition-2 slit, the edit boxes
(1110) capable of inputting the defining conditions,
such as the measurement code, vehicle height and a
parking lot designated, the OK button (1111) that
represents reflection of the setting, and the cancel
button (1112) to cancel the setting. The definition
image display area (1101) shows the currently selected
slit (1102), and the start point and the end point
(1103, 1104, 1105) on the slit are highlighted by dots.
The check box (1106) to select a definition mode is so
designed as to select either a partitioning point or a
start point.

In this screen image, it is arranged that one
base line and two partitions can be set on the slit.
Next, the operation of the screen image will be
outlined. The items written with white letters on the
dark background indicate the items to be input. By
selecting the partitioning point setting (corresponding

to the slit setting method in Fig. 7) in the definition
mode check box (1106), it becomes impossible to input
the coordinates of the start point in the edit boxes
(1108), which is normally capable of inputting the
5   coordinates of the partition-1 slit and it also becomes
impossible to input the coordinates of the start point
and the end point of the edit boxes (1109), which is
capable of inputting the coordinates of the partition-
2. The reason is as follows: when the other coordinate
10   values are set, those coordinates are automatically set
and therefore need not be input.

        If the origin (0,0) of coordinates of the
base line-0 slit is located at the lower left corner of
the screen and if X = 160 and Y = 005 are input as the
15   coordinates of the start point of the edit boxes (1107)
capable of inputting numeric values, this setting is
automatically reflected in the coordinates of the start
point of the edit boxes (1108) capable of inputting
coordinates of the partition-1 slit. When X = 160 and
20   Y = 235 are input as the coordinates of the end point
of the edit boxes (1107) capable of inputting coordi-
nates of the base line-0 slit, this setting is
automatically reflected in the coordinates of the end
point of the edit boxes (1109) capable of inputting
25   coordinates of the partition-2 slit. When X = 160 and
Y = 210 are input as the coordinates of the end point
of the edit boxes (1108) capable of inputting coordi-
nates of the partition-1 slit, this setting is

automatically reflected in the coordinates of the start
point of the edit boxes (1109) capable of inputting
coordinates of the partition-2 slit.

5   (In this example, after measurement, the
distance between the start point (1103) and the end
point (1104) of the base line-0 slit is set at "2.3m"
and the distance between the start point (1103) and the
partitioning point (1105) of the base line-0 slit is
set at "2.05m". In this example, cars are assigned to
10   different parking areas by classifying them at a
partitioning point of 210cm vehicle height. This value
can be decided arbitrarily.)

       Data is input in the edit boxes (1110)
capable of inputting the defining conditions, such as a
15   measurement code, a vehicle height and a designated
parking lot. In the 3-bit measurement code, entry is
denoted by 1 and before entry is denoted by 0. Because
the left bit of the three bits corresponds to the base
line-0 slit, the center bit corresponds to the
20   partition-1 slit and the right bit corresponds to the
partition-2 slit, a 3-bit measurement code 110, for
example, constitutes an instruction to guide a car to a
parking lot A that allows parking of vehicles with a
height of less than 2.1m. Further, another measurement
25   code 111 constitutes an instruction to guide a car to a
parking lot B that allows parking of vehicles with a
height of 2.1m and over.

       Description will be made of a screen image,

in which the areas of interest used by the definition
lines, including the base line and its partitions in
Fig. 12, which have varying lengths, are arranged on
the same line superposed one on top of another, and the
5 displayed items of the measurement code are set. Those
areas of interest correspond to the slits shown in Fig.
8. In Fig. 12, as in Fig. 11, the items written with
white letters on the dark background indicate the items
to be input. The window (1200) is formed in the same
10 pattern as a screen image in the window (1100) in Fig.
11, in which the area of interest used with the defini-
tion lines, including the base line and its partitions,
are arranged on the same line and the displayed items
of the measurement code are set.

15   In this screen image, the conditions for
slits of the base line and two partitions can be set.
The operation of the screen image will be outlined. By
setting the start point at the definition mode check
box (1206), it becomes impossible to input the coordi-
20 nates of the start point and the end point in the edit
boxes (1208), which is normally capable of inputting
the coordinates of the partition-1 slit, and it becomes
impossible to input the coordinates of the end point in
the edit boxes (1109), which is normally capable of
25 inputting the coordinates of the partition-2 slit.

If the origin (0,0) is located at the lower
left corner of the screen and if X=160 and Y=005 are
input as the coordinates of the start point in the edit

boxes (1207) capable of inputting the coordinates of
the base line-0 slit, this setting is automatically
reflected in the coordinates of the start point of the
edit boxes (1208) capable of inputting the coordinates
5 of the partition-1 slit. If X=160 and Y=235 are input
as the coordinates of the end point of the edit boxes
(1207) capable of inputting the coordinates of the base
line-0 slit, this will be automatically reflected in
the coordinates of the end point of the edit boxes
10 (1208) capable of inputting the coordinates of the
partition-1 slit and also in the coordinates of end
point of the edit boxes (1209) capable of inputting the
coordinates of the partition-2-slit. X=160 and Y=210
are input as the coordinates of the start point of the
15 edit boxes (1109) capable of inputting the partition-2
slit. (In this example, based on measurements, the
distance between the start point (1203) and the end
point (1204) of the base line-0 slit is set at "2.3m"
and the distance between the start point (1203) of the
20 base line-0 slit and the start point (1205) of the
partition-2 slit is set at "2.05m".

Then, data is input in the edit boxes capable
of inputting the defining conditions, such as a
measurement code, a vehicle height, a designated
25 parking lot. In this 3-bit measurement code, entry is
denoted by 1 and before entry by 0. The left bit
corresponds to the base line-0 slit, the center bit
corresponds to the partition-1 slit and the right bit

corresponds to the partition-2 slit. Accordingly, a
measurement code 110 constitutes an instruction to
guide to a parking lot A that allows parking of
vehicles with a height of less than 2.1m. Another
5 measurement code 111 constitutes an instruction to
guide to a parking lot B that allows parking of
vehicles with a height of less than 2.1m.

The slit position information used in this
embodiment is stored in the slit definition and
10 detection information shown in Fig. 5. The information
(501) about the base line-0 slit is a list pointed by
the start pointer (500) of the slit definition and
detection information. The coordinates of the start
point are stored in the start point X (557) and the
15 start point Y (558). The coordinates of the end point
are stored in the end point X (559) and the end point Y
(560). Information about (502) about the partition-1
slit contains the coordinates of the start point and
the end point of the partitioned slit-0 in a list
20 pointed by the pointer (551) of the information (501)
of the base line-0 slit. Information (502) of the
partition-1 slit has the pointer pointing to the
partition-2 slit.

An applied example of the present invention
25 is shown as follows. A video camera is installed
overhead at the entrance for automobiles to take
pictures of their roofs. The above-mentioned slit is
provided at right angles with the longitudinal

direction of a car, which makes it possible to estimate
the width of the car. By this arrangement, stopping
the advancing car or guiding to an appropriate route
can be done automatically.

5   According to the present invention, it is
possible to provide, in a screen image, defining means
along a straight line, consisting of the base line and
its partitions and also provide a plurality of defined
areas of interest for monitoring, so that it becomes
10 possible to accurately measure the height of a moving
object in an input image, including video camera
images, efficiently and easily.